Shear Testing of Precast Concrete Sandwich Wall Panel Composite Shear Connectors

Taylor Sorensen, Jaiden Olsen, Dr. Marc Maguire

taylorsmail@msn.com, jaidenolsen@gmail.com, m.maguire@usu.edu

UtahStateUniversity
DEPARTMENT OF CIVIL ENGINEERING

Research Significance

- The push for more sustainable engineering designs in the past 20 years has encouraged greater focus on thermally efficient connections for concrete wall panels (shown in Fig. 1). One of the most challenging aspects of insulated panel design is creating composite action between the concrete wythes, without causing a thermal bridge. Thermal bridging occurs when the thermally efficient foam is penetrated by a more conductive material like concrete or steel, and can greatly reduce the R value of the component.
- The objective of this research is to use existing information and new testing to develop general tools for use in every day practice to better generalize composite action in wall panels.

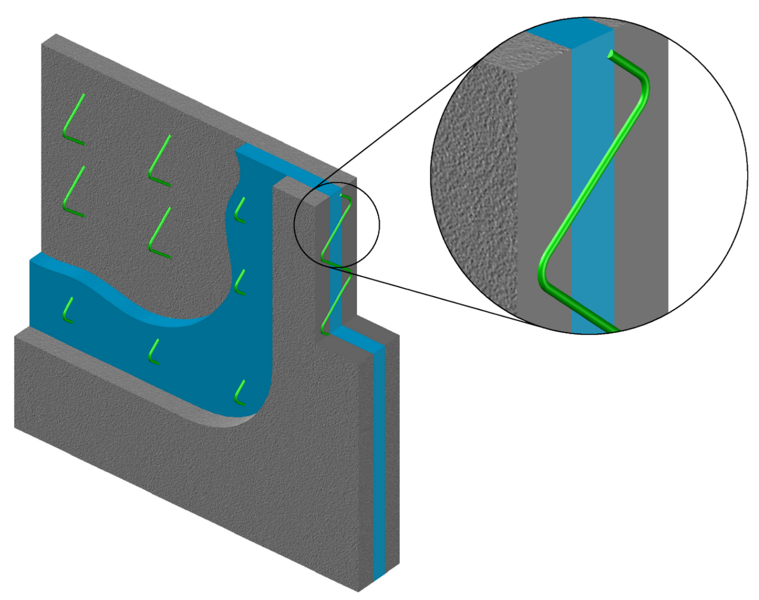

Figure1- Concrete Sandwich Wall Panel with Company A Connections

Test Method

- Specimens were each 3 ft. wide by 4 ft. tall
- Each of four connectors manufactured using Glass Fiber Reinforced Polymer (GFRP) but with differing processes and companies
- Specimen depth consisted of three concrete wythes and two foam wythes
- Wythe dimensions were either 3"x3"x6"x3"x3" or 4"x4"x8"x4"x4"

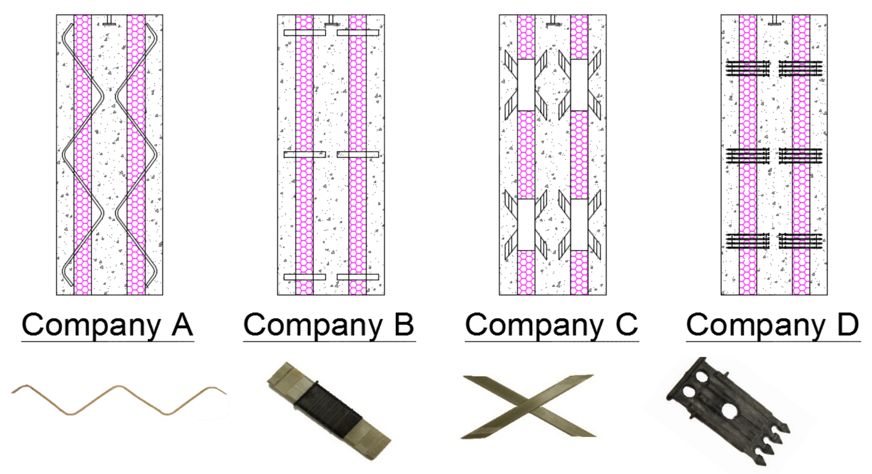

Figure 2- Four Types of Push-off Concrete Test Specimens

- Foam types used included Extruded Polystyrene (XPS), Polyisocyanurate (ISO), Expanded Polystyrene (EPS)
- Concrete reinforced by #3 rebar spaced at 6" on center
- Load applied to center wythe with relative displacement measured of inner wythe to outer wythe

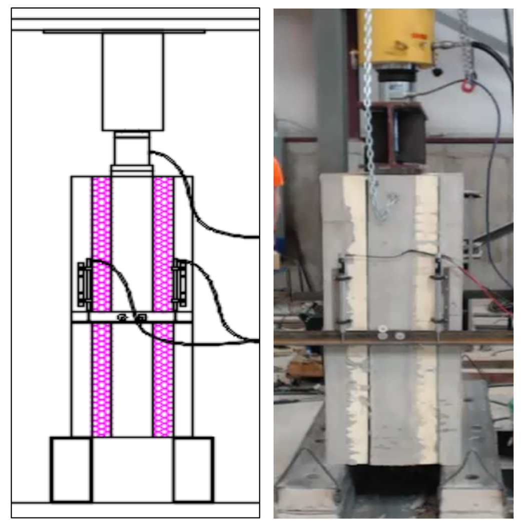

Figure 3- Push-off Test Setup

Results

- Many connectors maintained significant load while continuing to deform; others failed soon after they reached peak load
- Foam type and bond between concrete and foam interface had insignificant effect on strength or ductility, though unbonded specimens showed consistent reduction in capacity

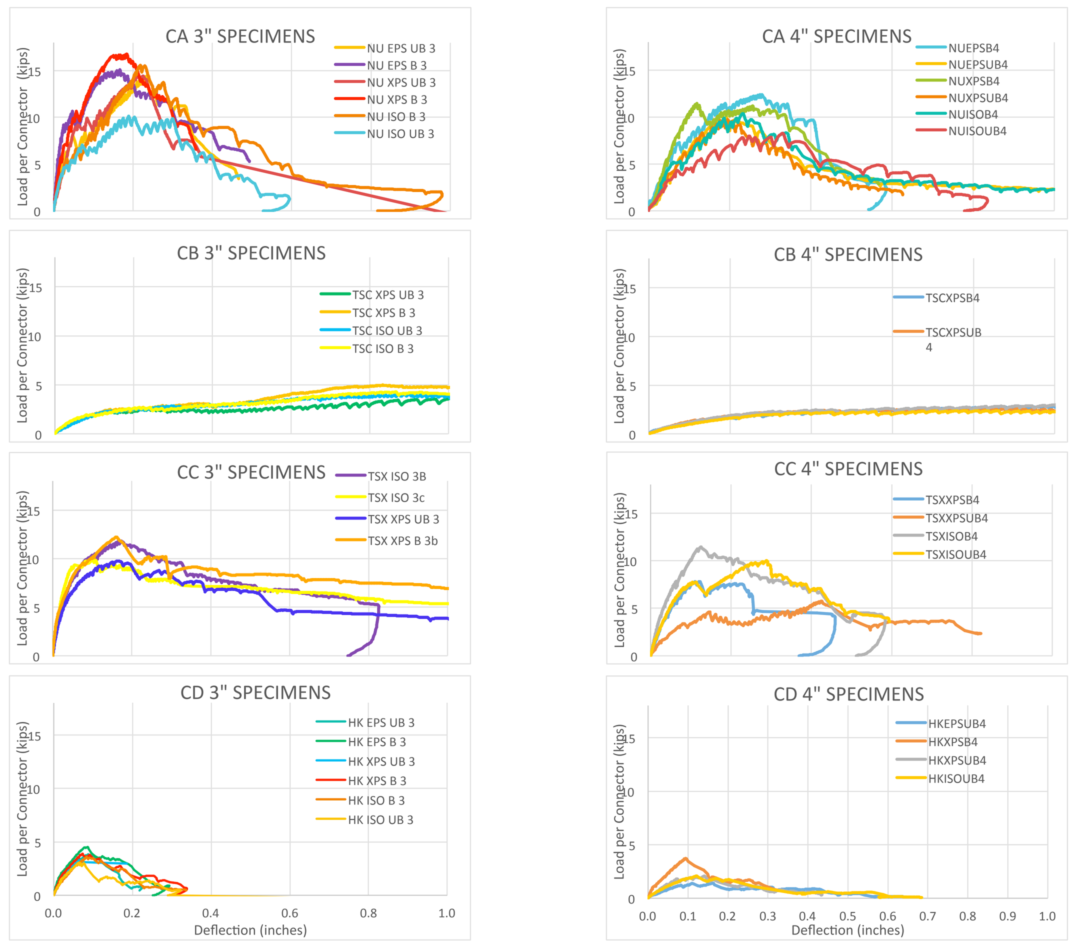

Figure 4- Shear Load vs. Deflection for specimens

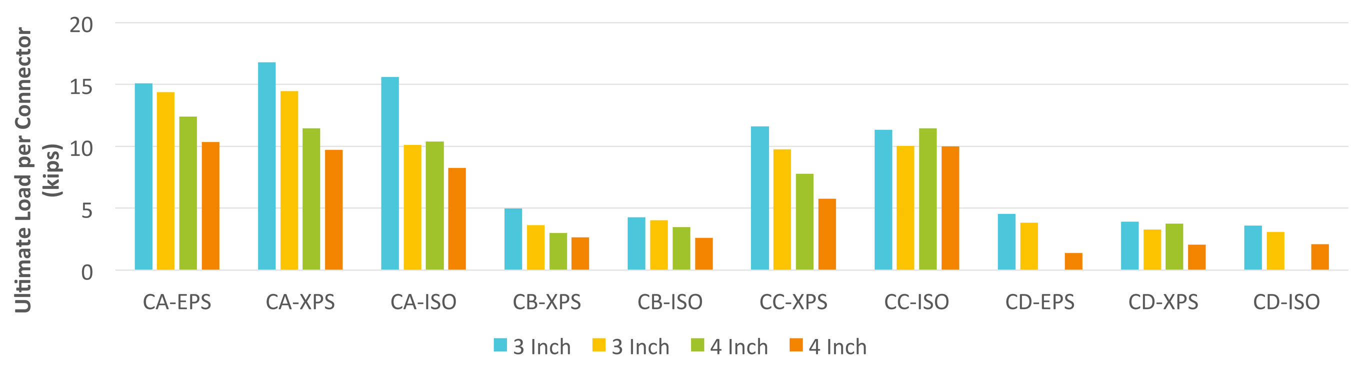

Figure 5- Ultimate Load per Connector Comparison

- Elastic limit load (F_E) and elastic stiffness (K_E) identified visually
- Aside from strength and stiffness, other factors that should be considered include cost, ease of fabrication, and durability

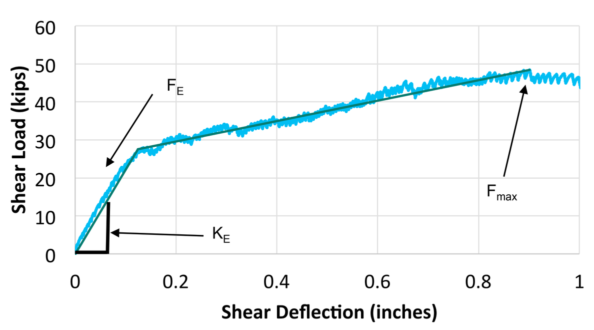

Figure 6- Determination of Elastic Load and Stiffness

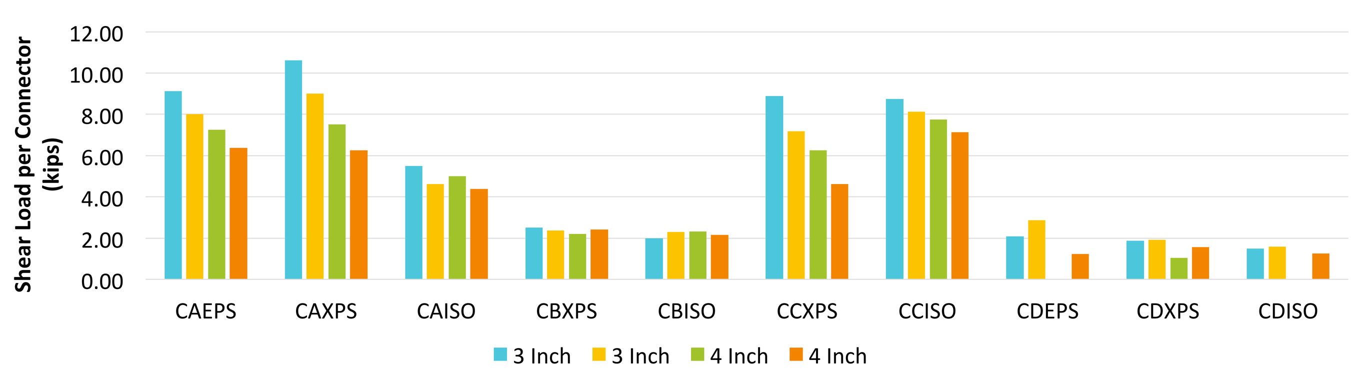

Figure 7- Elastic Limit (F_E) Comparison per Connector

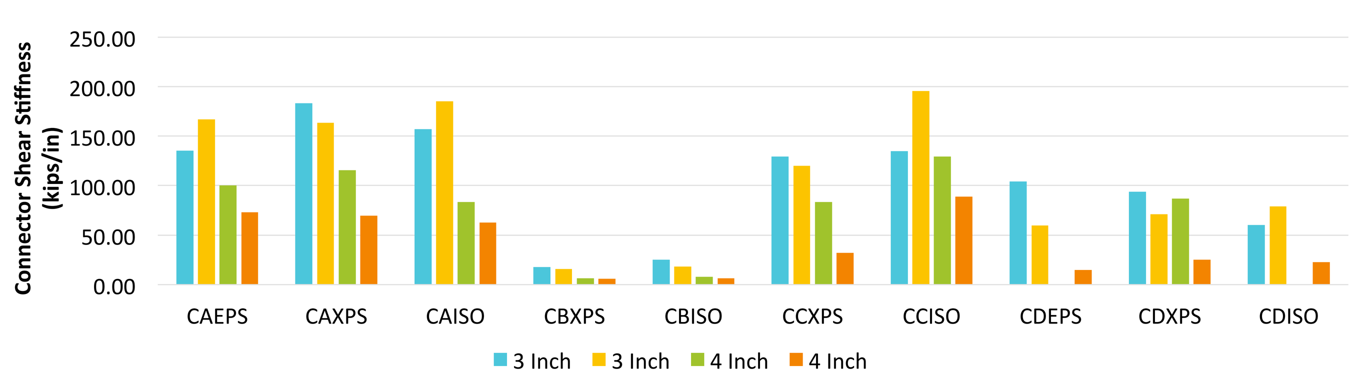

Figure 8- Elastic Stiffness (K_E) Comparison per Connector

Simplified Model

- Analytical model developed using personal matrix analysis software
- Model panels with only beam and spring elements

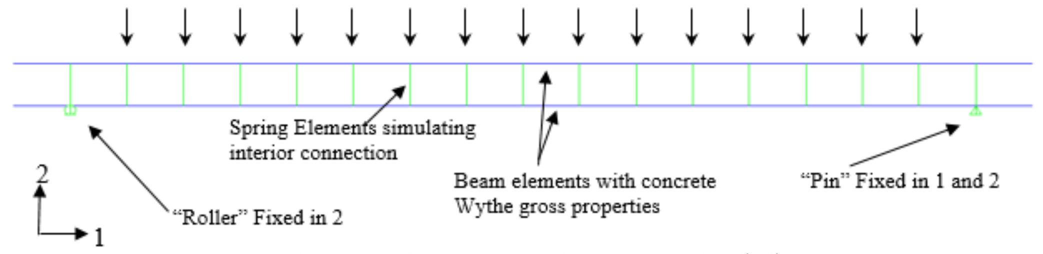

Figure 9- Beam Spring Model

- Beam elements assigned individual concrete wythe properties, separated by distance between the concrete wythe centroids
- Springs placed to represent both connectors and insulation stiffness
- Equivalent point loads placed for corresponding applied pressure
- Model agreed with tested results, but only Connector B was modeled
- Further testing is currently in progress

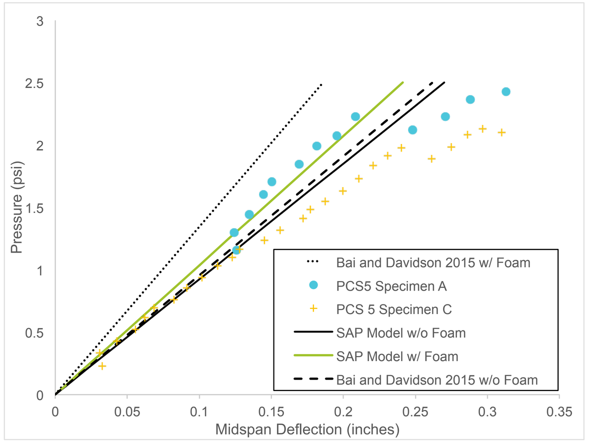

Figure 10- Deflection and Resistance Comparison (Naito)

Conclusion

- Connectors provide less strength and stiffness with larger wythe thicknesses or when debonded
- Stiffness and strength were found to be unrelated and likely due more to the orientation of the connectors
- Simplified beam spring model is accurate as compared to literature
- A triangular distribution of shear connectors is the most structurally efficient (more connectors lumped toward ends)
- Composite action was shown to increase with the increase of shear connectors

References

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